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Determination of specific molecular markers of biomass burning in lake sediments

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Fire influences regional to global atmospheric chemistry and climate. Molecular markers of biomass burning archived in lake sediments are becoming increasingly important in paleoenvironmental reconstruction and may help determine interactions between climate and fire activity. One group of these molecular markers is the monosaccharide anhydrides levoglucosan, mannosan and galactosan. Several aerosol studies and recent ice core research use these compounds as a marker for biomass burning, but studies from lake sediment cores are rare. Previous sediment methods used gas chromatography – mass spectrometry and required derivatization of samples. Here, we present a high performance anion exchange chromatography-mass spectrometry method to allow separation and detection of the three monosaccharide anhydrides in lake sediments with implications for reconstructing past biomass burning events.

We validated the method by quantifying levoglucosan, mannosan and galactosan in selected sediment core samples from Lake Kirkpatrick, New Zealand. The freeze-dried, milled and homogenized sediment samples were first extracted with methanol by pressurized solvent extraction, pre-concentrated and finally separated and analyzed by high performance anion exchange chromatography-mass spectrometry. We compared these isomers with macroscopic charcoal concentrations, as charcoal is a well-known proxy for biomass burning. In addition, we applied the method to a sediment core from Lake Petén Itzá, Guatemala to prove the suitability of these markers for reconstructing biomass burning history over the entire Holocene.

In the Lake Kirkpatrick samples, levoglucosan, mannosan and galactosan concentrations significantly correlate with macroscopic charcoal concentrations. The three isomers are present in samples without any macroscopic charcoal, and may reflect the presence of microscopic charcoal. Levoglucosan/mannosan and levoglucosan/(mannosan+galactosan) ratios differ between samples with high macroscopic charcoal concentrations and samples without any charcoal. These ratios may help determine not only when fires occurred, but also past changes in the primary burned vegetation. However, the possibility that these isomer ratios help differentiate changes in burned vegetation needs further evaluation. The preliminary results of the Lake Petén Itzá samples demonstrate the occurrence of all three molecular markers in the entire core, covering the past approximately 10,000 years. The three monosaccharide anhydrides levoglucosan, mannosan and galactosan may be an additional tool for reconstructing past fire events over decadal to millennial time scales in sediment cores.